
Space Weather Technical Forecast

Issued on Thursday, 04 January 2024 at 13:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Further M-flares likely with a slight chance of X-flares. S1 Proton Storming continues, reducing risk from day 2.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity has been Moderate with the peak flare an M3.8 observed at 04/0155 UTC from AR3536 in the NE. There are five sunspot regions on the disc. The most notable group remains AR3536 which was the source of an X5.0 flare on 31 Dec. This spot contains a small delta spot in its north-south aligned magnetically complex leading portion. The remaining spots are all smaller and simpler at this time, with the emergence of a new region to the east of AR3536.

A number of CMEs were visible in imagery, however these have all been assessed as being off the Earth-Sun line with no Earth-directed CMEs occurring.

Solar Wind / Geomagnetic Activity: Solar winds were indicative of a weak fast wind from CH86/-, with an embedded CME glancing blow at 03/1420 UTC. Speeds were initially 420 km/s before quickly rising to around 450-490 km/s upon the arrival of the CME. Solar wind speeds then gradually fell to around 440km/s where they remained for several hours. Density started below average, but soon increased to above average levels for a few hours after the CME arrival, peaking at 18ppcc at 03/1533 UTC, before returning to average levels by the end of the period. Interplanetary Magnetic Field (IMF), Bt, initially weak (5nT), but increased to peak 10nT at 03/1425 UTC, before gradually declining back to weak levels. The north-south component, Bz varied weakly throughout, with one notable period of persistently negative between 03/1800-2100 UTC, before becoming largely positive. Phi angle was generally negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux has been on an increasing trend, rising above the S1/Minor Storm threshold from 03/2005 UTC. GOES16 high energy (greater than 2MeV) electron flux ranged was mainly at background. The 24-hour fluence was below Active throughout. The 04/0000 UTC observation was 2.84e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Generally moderate activity is considered likely, with isolated M-flares and a slight chance of an X-class flare.

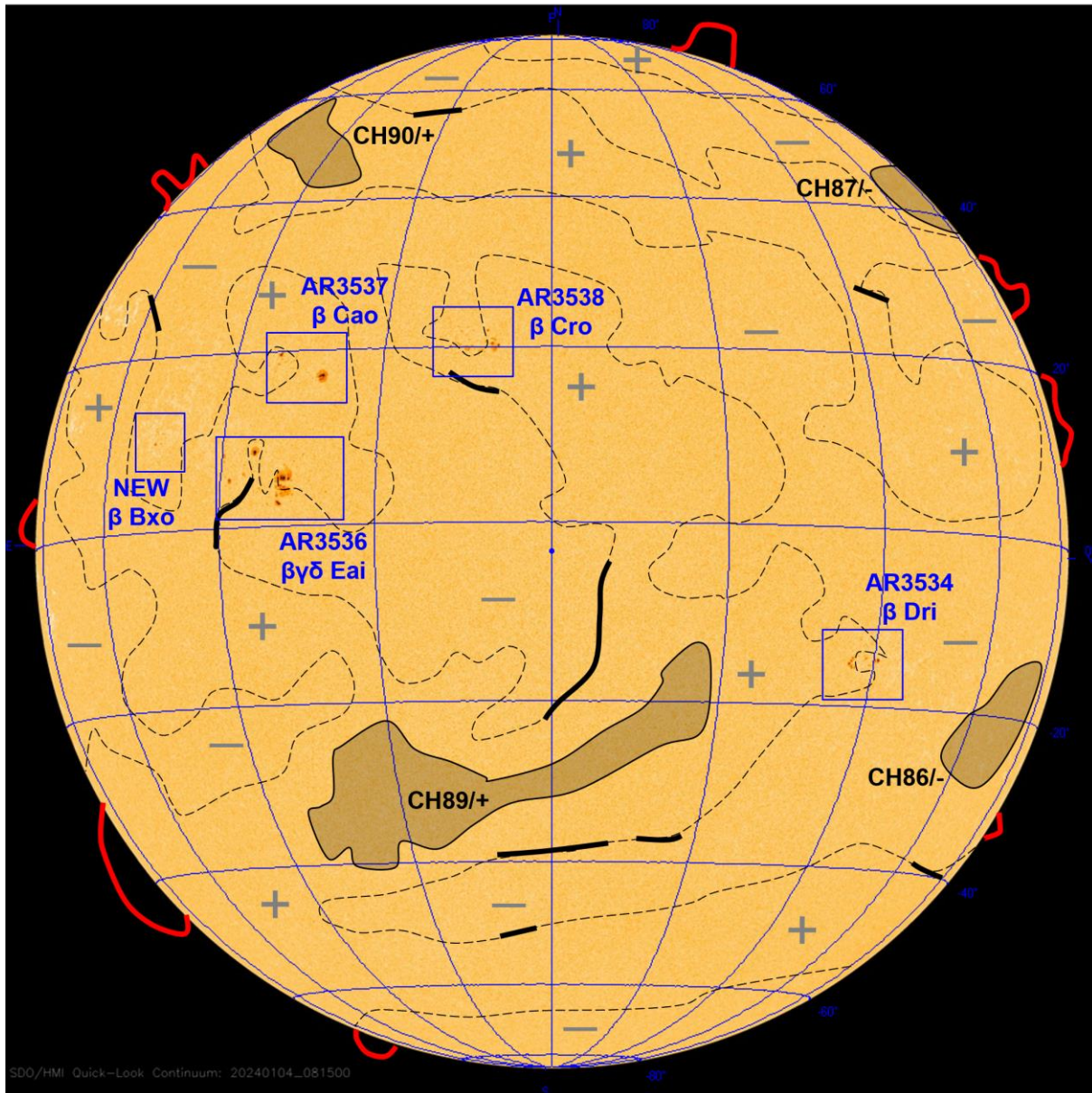
Solar Wind / Geomagnetic Activity: No CMEs feature in the forecast period. The fast winds from CH86/-, with current speeds of 440 km/s are expected to continue to wane, perhaps falling to background levels through days 2-3 (05-06 Jan). The next expected enhancement in solar winds is from the high speed stream of coronal hole 89/-, which may begin to arrive from late day 3 or into day 4 (06-07 Jan), with wind speeds of 450-500 km/s.

Quiet geomagnetic activity is initially expected, with a chance of Unsettled periods. From day 3 (06 Jan) onward there is an increasing chance of Unsettled or Active periods and a slight chance of isolated G1/Minor Storm intervals upon the arrival of coronal hole 89.

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Energetic Particles / Solar Radiation: GOES16 high energy proton flux is above the S1/Minor Storm threshold in response to recent significant flare activity. Proton flux levels are expected to continue to exceed S1/Minor storm levels on day 1 (04 Jan) with a chance of continuing into day 2 (03 Jan), then a slight chance on subsequent days, dependent on any further notable flares occurring. GOES16 high energy electron flux is likely to remain near background, perhaps briefly rising to Moderate later in the period, with the associated fluence remaining below the Active level.

Figure 1. Solar Analysis Valid 04/0800 UTC.



Key: Filament --- , Prominence --- , Magnetic Field Line --- , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson alpha-beta-gamma-delta and Zurich-McIntosh Axx etc.

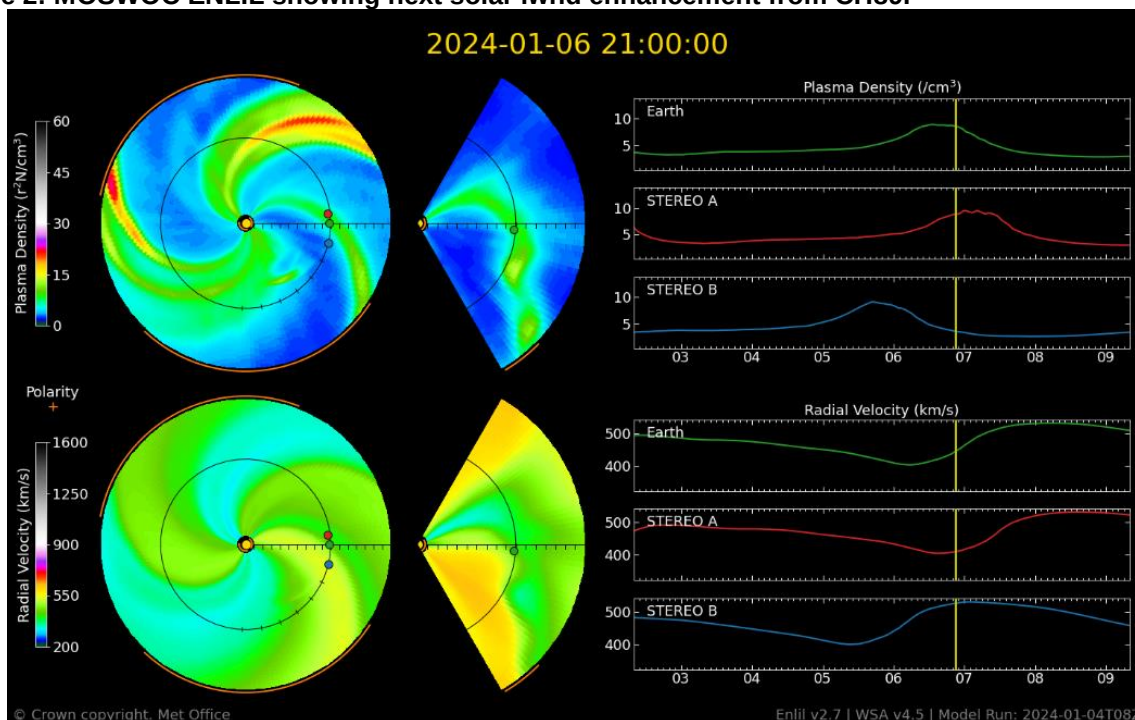
Geomagnetic Storms:

Two CMEs gave minor glancing impacts on Earth on the 03 Jan. However despite these CME arrivals, minimal geomagnetic effects have been observed. Otherwise, fast winds from CH86/-, with current speeds of 440 km/s are expected to continue to wane, perhaps falling to background levels through days 2-3 (05-06 Jan). The next expected enhancement in solar winds is from the high speed stream of coronal hole 89/-, which may begin to arrive from late day 3 or into day 4 (06-07 Jan). This feature is rather elongated and has a weak leading portion, whereas the trailing section of this coronal hole is darker and more likely to give faster windspeeds. Therefore solar wind speeds of 450-500 km/s may be reached this coming weekend, perhaps with faster speeds around 550 km/s from 08 Jan.

Quiet geomagnetic activity is initially expected, with a chance of Unsettled periods. From day 3 onward there is an increasing chance of Unsettled or Active periods and a slight chance of isolated G1/Minor Storm intervals upon the arrival of coronal hole 89.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	1	1	5	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: MOSWOC ENLIL showing next solar iwnd enhancement from CH89.



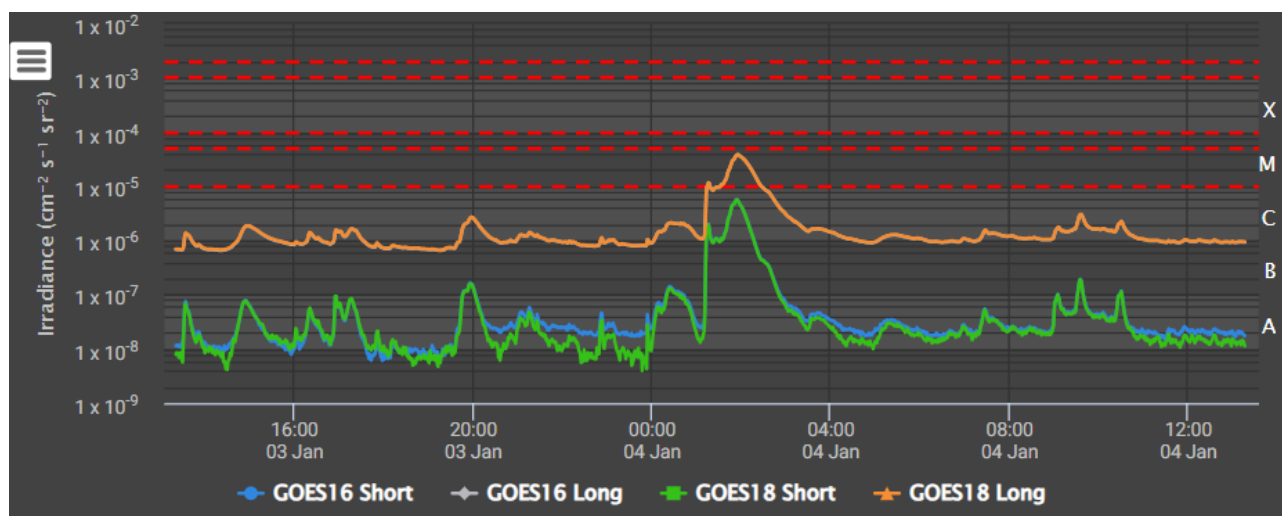
Radio Blackouts - X-Ray Flares:

Activity has been Moderate with the peak flare an M3.8 observed at 04/0155 UTC from AR3536 in the NE. Generally moderate activity is considered likely, with isolated M-flares and a slight chance of an X-class flare, chiefly originating from AR3536.

There are five sunspot regions on the disc. The most notable group remains AR3536 which was the source of an X5.0 flare on 31 Dec. This spot contains a small delta spot in its north-south aligned magnetically complex leading portion. The remaining spots are all smaller and simpler at this time, with the emergence of a new region to the east of AR3536.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	55	55	55	55
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: 24 hours X-ray trace shwoing M3.8 from AR3556.



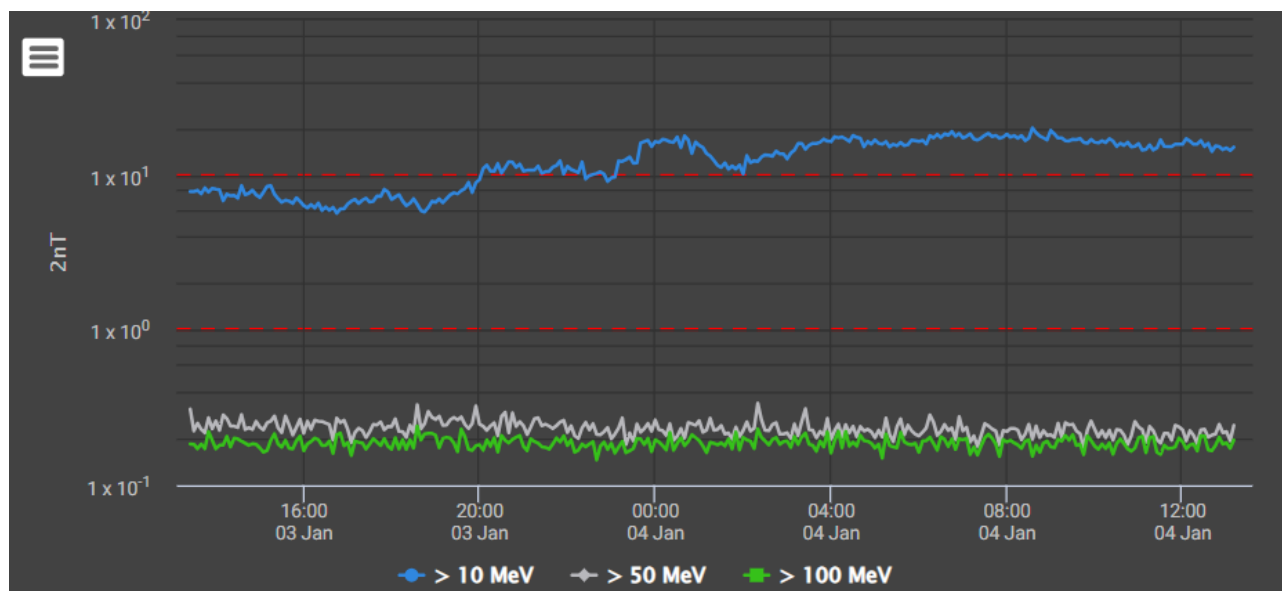
Solar Radiation Storms - (High Energy Protons):

GOES16 high energy (greater than 10MeV) proton flux is above the S1/Minor Storm threshold currently and now on a steady trend. This is the result of the recent large flares from AR3536. It is expected the >10MeV proton flux will continue to be just above the S1/Minor Storm threshold at first on day 1 (04 Jan), before slowly dropping towards background or slightly elevated, due to uncertainty into the reduction rate of the proton flux, there is a chance the S1/Minor storm threshold could also be exceeded initially for day 2 (05 Jan). Any further significant flares, primarily from this region, will bring a risk of further increases in the observed proton flux. This gives a slight chance of reaching the S1 Minor Storm level on days 3 and 4 (06-07 Jan) as the region moves further west on the disc and into a more central location.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	Yes	100	40	10	10
Very Active	$\geq \text{S3}$ *	No	1	1	1	1

* $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)

Figure 4: 24 hour Proton (10 MeV) trace.



High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) as observed by GOES-16 continues to persist at mostly background levels. The weak fast wind of CH86/- is now beginning to wane. Only minimal geomagnetic activity observed at it's peak, with two glancing blows only giving unsettled (Kp3) geomagnetic activity for a time. With no further CME impacts expected, mainly background flux is predicted to continue with a chance of reaching Moderate during periods of diurnal maximum.

The associated 24 hour fluence is forecast to persist at background, with a largely flat trend staying well below the Active ($1\text{e}8$) threshold. This is supported by REFM which is currently giving good guidance.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	5	5
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 5: MOSWOC REFM electron fluence (integrated flux) forecast, observations and recurrence.

